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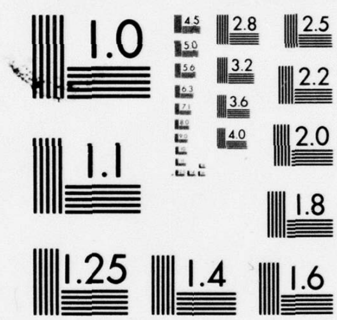

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UNDER CONTRACT N00024-71-C-1185, Task 8103
1 April - 30 June 1971

NAVAL SHIP SYSTEMS COMMAND
Contract N00024-71-C-1185
Proj. Ser. No. SF 11121106 and 11121104, Task 8103

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~~UNDER CONTRACT N00024-71-C-1185, Task 8103 (U).~~

1 April - 30 June 1971

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NAVAL ~~SHIP SYSTEMS~~ COMMAND

Contract N00024-71-C-1185

Proj. Ser. No. SF 11121106 and 11121104, Task 8103

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A. Single-Target Automatic Classifier Development Program (J. F. Willman)

(U-FOUO) Work has continued on development of the single-target classifier. Substantial progress has been made toward completing the hardware and software required for the data collection system. Significant improvements have been effected in the computer algorithms to be used for clue extraction. Progress toward developing techniques for combining the clues from the various scanners and obtaining a single-ping classification decision has also been considerable.

(U-FOUO) The status of the single-target classifier program was reviewed for Messrs. W. Thompson and K. E. Buske, and Miss D. Gauggel of NAVSHIPS, Code 901, at ARL on 21 May 1971. More recent results on this program are briefly summarized in this section of the report.

1. Data Collection

(U-FOUO) Work during this quarter has been to make the data link from the DDP 516 to the CDC 3200 operational. This data link is necessary for efficient A/D conversion of PME sonar data, a great quantity of which is going to be required for developing the automatic classification system. All of the construction and installation work has been completed and checkout of the data link is currently in progress. Specific details of this work are contained in Section C, Systems Engineering Section, of this report.

2. Research and Development

(U-FOUO) Additional sequences of PME submarine target data from the audio and video scanners have been converted to digital format and analyzed.

(U-FOUO) In this manner the clue extraction algorithms are being refined for these processors. For the split-beam processor algorithm development work, scaled model data and reverberation that had previously been recorded at Lake Travis are being used. This work on clue extraction, as well as the effort on combining these clues to effect a classification decision, is reviewed in the following paragraphs.

a. Audio and Video Processors

(U-FOUO) Algorithms for extraction of various parameters were further refined using the available digitized data and diagnostic routines described in QPR No. 1. Special attention was given to handling the video data, since it arrives in the CDC 3200 separated from the audio and split-beam data, and there are so many video data points to be handled.

(C) The method of range measurement was established for all processors to be the "center of target" measure defined as

$$\text{Range} = \frac{\sum_i R_i E_i}{\sum_i R_i} ,$$

where R_i is the range to the ith envelope sample E_i, and the summation is over the extracted target length. The video processor also sums over bearing samples contained in the extracted target area, so that a "center of target" is obtained for both range and bearing.

(C) This method was chosen after comparing various methods of range measurements on a high S/N target sequence, with results shown in Fig. 1. For this bow aspect submarine, the leading edge measurement is as good as any, whereas the trailing edge and peak estimators are poor.

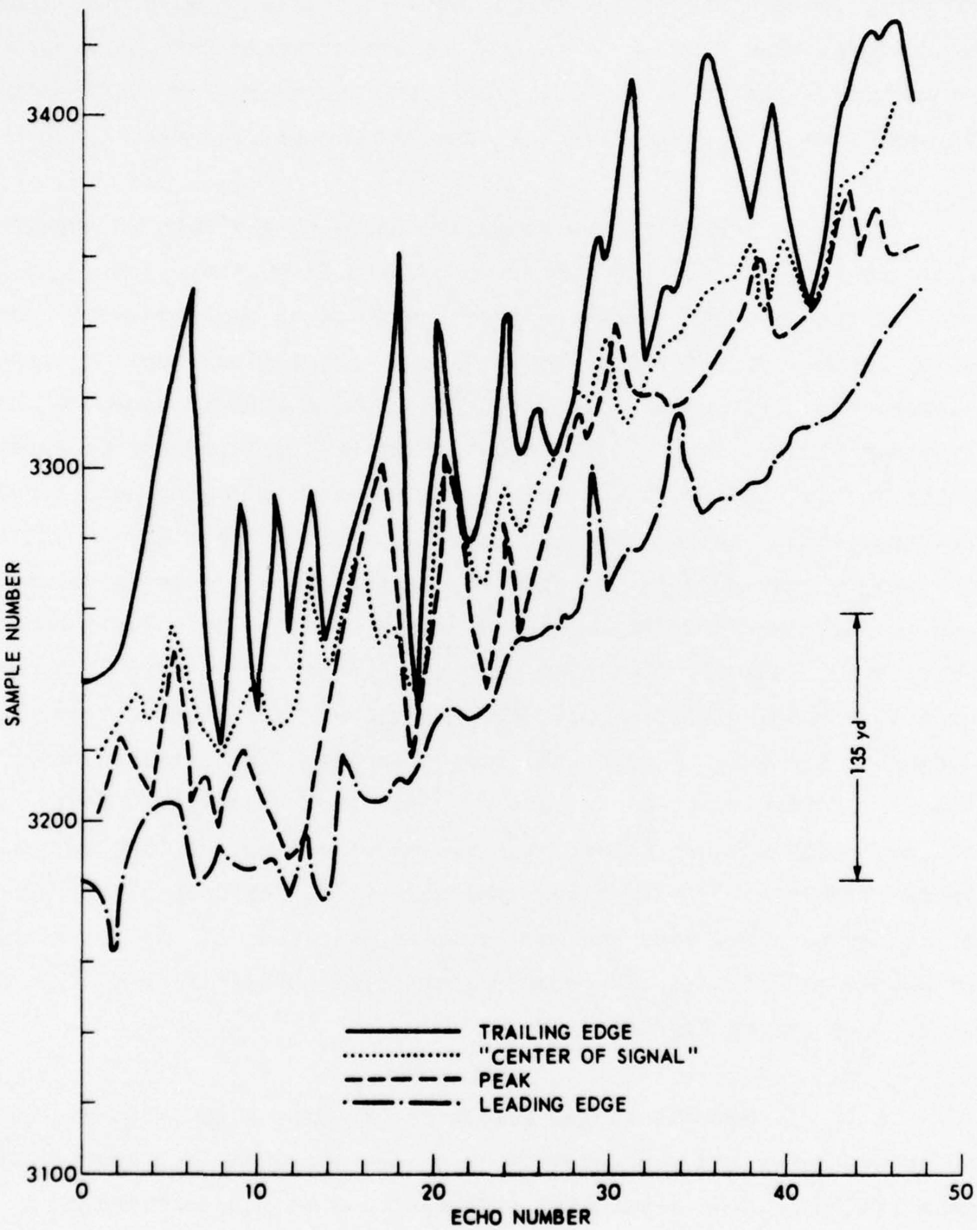

FIGURE 1
COMPUTED RANGE VERSUS PING NUMBER
FOR SEVERAL METHODS OF ESTIMATION
BOW SUBMARINE TARGET
NEAR-CONSTANT RANGE RATE

ARL - UT
AS-72-1
SKM - DR
1-7-72

(C) However, for a stern aspect target this relationship might be expected to reverse. The "center of target" estimator would obviously not be greatly affected by an aspect change, and the track for this measure is nearly as good as the leading edge measurement for this target.

(U-FOUO) A problem was noted in the range estimate procedure shown in Fig. 1: All the estimates contain large range jumps around the (expected) smooth track. Since the range as measured here uses a clock (sine wave reference) derived from the original tape to compute elapsed time from sonar zero-time, the problem must be caused either by sonar timing, faulty A/D, target structure, or programming errors. Since several different programs resulted in nearly identical results, the programming seemed the least likely source. However, to test both the target structure and programming processes, a simulated target was generated, comprising 30 reflectors whose coefficients of reflection were varied randomly from ping to ping according to either a Rayleigh or a log-normal distribution. This target was added to reverberation data from the same pings as the target in Fig. 1 to obtain similar S/N and was tracked using one of the programs just discussed. Even the range-to-peak measure showed maximum variations around the "correct" track of only 6 yd, even though the target "scintillation" for some of the synthesized data was much greater than that of the real target. It was concluded that the problem comes from sonar timing or A/D, with sonar timing the most likely.

(U-FOUO) Several target structure measures were proposed for the audio processor and some were tried on the extremely limited amount of data available. No meaningful statement can be made concerning a single-ping target structure parameter as yet, but it is felt that the process of merely counting the number of relative peaks, as did TRESI, can be improved upon.

b. Split-Beam Processor

(C) Work on data from the split-beam processor has been directed primarily toward refinement of the computer algorithms used for automatic extraction of aspect angle, true length, signal-to-noise ratio (S/N), and line-likeness. The line fitting program yielding aspect angle and line-likeness has been improved considerably; however, more work is needed to determine the most reliable measure of line-likeness from several now being tried. As a means of testing the statistical reliability and accuracy of extracted clues, scaled model data and reverberation data recorded at Lake Travis are being used. In this way, we can control S/N of the split-beam scanner data to provide more realistic tests of our clue extraction algorithms. During the last period, S/N has been varied from +6 dB to 0 dB (as measured on an rms basis for each beam). Cumulative distributions for 100 pings of data at a given S/N and a known aspect angle have been plotted for all clues extracted. These results have been interpreted; the conclusions drawn have been useful in focusing our attention on specific problems associated with the automatic clue extraction. These problems are presently being identified and eliminated wherever possible. Results achieved to date are quite encouraging.

B. Classification Section
(J. F. Willman)

(U-FOUO) Development of the split-beam crosscorrelator is the principal task being pursued in the Classification Section, although work continues at a lower level of effort on the model data acquisition system and the study of submarine echo structure.

1. Model Data Acquisition System

(U-FOUO) Directional patterns were obtained for projectors and hydrophones to be used at Lake Travis. The frequency characteristics of directionality and amplitude response were also measured and documented. After fabrication of a suitable mounting bracket, the projector and receiver arrays were attached to a column hanging from a barge at Lake Travis. A cylindrical target, intended for furnishing replicas of the transmitted pulse in the water, was fabricated. A new receiving system, that was obtained from another division of ARL, is currently being checked out to determine its applicability to our future model data acquisition efforts.

2. Split-Beam Crosscorrelator

(U-FOUO) The inclusion of the split-beam crosscorrelator in the single target (automatic) classifier now being developed under this contract has resulted in putting a higher priority on completion of this split-beam processor. Accordingly, a major portion of the work in the Classification Section has been the refinement of the split-beam concepts and techniques. Progress on this part of the program is documented in Section A.2.b. of this report.

(U-FOUO) Although presently assigned a lower priority, work on more general aspects of the split-beam classification problem, e.g., spatial coherence of target echoes and surface reververation, has continued at reduced level.

3. Echo Structure Studies

(U-FOUO) The technical memorandum on analysis of echoes from the nose section of the scale model at Lake Travis was issued on 6 May 1971

(U-FOUO) (see Section J of this report). After work on instrumentation at Lake Travis, some peak and energy level aspect dependency patterns were obtained from the model submarine at the end of the quarter. Efforts on analyzing these data and obtaining further results will continue, the aim being that of defining parameters useful for present and future classification work.

4. Target Strength Conference

(U-FOUO) A conference on target strength measurement using full-sized and scale model submarines was held at NSRDC on 30 June 1971. Dr. J. F. Willman of ARL attended the meeting. Others at the conference were:

Kenneth E. Buske, NAVSHIPS, Code 901
Theo Kooij, NSRDC, Code 931
G. R. Spalding, NAVMAT, Code 03416
J. L. Reeves, NAVSHIPS, Code 901L
W. R. Schumacher, NUSC/NL, Code TA11
F. J. Keltonic, NUSC/NL, Code TA111
J. F. Willman, ARL/UT, Signal Physics
John Tewksbury, NAVSHIPS, Code 9024
Budd Adams, NRL, Code 8160

No serious discrepancies between scale model results observed at ARL and full-sized submarine data were noted. All participants at the conference were in good agreement as to valid methods of obtaining measurements and their possible interpretation, although minor differences were noted in the actual techniques used at various facilities. Comparison of scale-model target strength data to measurements from full-sized submarines was limited because the ARL scale model has not been used except in submarine classification studies and relative target strength variation with aspect angle only was obtained as required to support the classification work. Target strength measurements on the ARL 1/24 scale model of the USS SKIPJACK (SSN 585) should be made and compared to real submarine data in order

(U-FOUO) to validate the use of models with large scaling factors; this effort will be pursued later on a noninterference basis.

(U-FOUO) Estimates of probability distribution curves for split-beam processor clues were made on 26 May 1971, for the purpose of programming the classification decision. Similar estimates from the audio and video processors were also provided to allow optimum combining of clues from the various processors.

C. Systems Engineering Section
(W. D. Howard)

(U-FOUO) Engineering effort during the second quarter was primarily devoted to finishing the data collection system for the single target classifier described in the first quarterly report. This system has become operational, with some modification, and data collection will begin immediately. A limited effort has continued on the baseline sonar display system, the aim being to construct a solid-state prototype for demonstration at sea. The following paragraphs summarize the two projects in more detail.

1. Single Target Classifier

(U-FOUO) The data collection system for the single target classifier has been realized as described in the first quarterly progress report, with one exception. The digital beamformer was deemed unsuitable for this project; therefore, the AN/SQS-23 mechanical video scanner was used to provide video data to the Honeywell computer via the analog-to-digital (A/D) converter.

(U-FOUO) Two synchro-to-digital (S/D) converters were purchased and interfaced to the computer to provide the ship's course and target

(U-FOUO) bearing inputs. A sample clock generator was designed and built to provide sampling pulses, which are phase-locked to the PME reference signal, to the A/D converter. This technique is necessary to eliminate the effects of tape wow and flutter.

(U-FOUO) The most troublesome problem was encountered in the design of the scaling amplifiers required to match the signal impedances and amplitudes to the A/D converter. The inputs had to be differential to eliminate a ground loop with the sonar, and the phase sensitive split-beam processor required that the scaling amplifiers have excellent phase response at 18 kHz. A design was found which worked satisfactorily, and 4 amplifiers were operating late in the quarter.

(U-FOUO) The data link was plagued throughout the quarter by a reliability problem associated with certain data bits. It was mentioned in the first quarter that operating logic level margins were suspected, but unfortunately consultations with CDC led us to look elsewhere for the problem. Late in the quarter it was decided to modify the logic level converters to exactly match CDC published nominal logic levels. It appears that this change has solved the reliability problem. Occasionally other problems arise in the data link; however, these occur so seldom that they should not seriously impede the data collection. These problems will be addressed after the single-target classifier has become operational.

2. Baseline Sonar Display

(U-FOUO) A modest effort continued on the baseline sonar during the quarter. Another AN/UQS-1 display console was acquired for modification and a design was completed for an all solid-state display system. The original display was used for operator testing in the playback facility during the quarter, and the second AN/UQS-1 unit allowed us to begin

(U-FOUO) building the solid-state display prototype without disturbing the testing program. Solid-state deflection amplifiers and a high voltage power supply were built and tested, and planning for the remainder of the system has begun. It is expected that the single beam classifier will be used with the baseline sonar, thus modifying the display timing considerations somewhat. These requirements will be anticipated wherever possible in the solid-state baseline display prototype.

D. Naval Ship Systems Command Classification Advisory Panel (S. P. Pitt)

(U-FOUO) There was no activity of the Classification Advisory Panel during the first quarter.

E. Systems Analysis (S. P. Pitt)

1. Data for CAD

(U-FOUO) Development of software for the generation and processing of three-dimensional (range, bearing, S/N) data from the AN/SQS-23 MIP tapes was begun during this quarter. This being a large body of data, it was decided that the standard Signal Physics data identification record used with all digital data should be changed from the present 20-word format to a 121-word format. This format, in that it allowed much more flexibility in the use of words in the ID, in turn required a new standard format for the normal sonar and tape handling parameters. The new format is presented in the Computer Applications Section.

(U-FOUO) In order to assure proper data production for the General Electric and TRACOR tasks using this three-dimensional data, a meeting was held at ARL on May 19, to discuss formats, types of data available, processing parameters, and quantities of data needed to provide useful results.

(U-FOUO) Attendees were:

Bill Butler, TRACOR
Jerry Dow, TRACOR
Loyd Hampton, ARL
Dave Jordan, General Electric
John Lindhuber, General Electric
Ken Buske, NAVSHIPS
Pat Pitt, ARL
Hugh Reeder, TRACOR
Ken Vaughan, ARL
Don Winfield, General Electric
Chuck Wood, ARL
Dolly Gauggel, NAVSHIPS

(U-FOUO) As a result of the meeting, the following decisions were made:

(1) Data from FM transmissions would be used, especially so that performance comparisons can be made with operator tests being conducted at ARL.

(2) ID records would be as described in the Computer Applications Section.

(3) ARL would supply processed data (with own ship's motion removed, if possible) in the form of digital records containing a list of "events", or possible targets, which have been selected on the basis of a signal-to-noise ratio (S/N) criteria. The data would represent detected and averaged (on each beam) envelope data from the digital beamformer, with S/N measured by comparing the value at a particular range and bearing to the average of some number of range-bearing points around that point. A threshold which would provide approximately a 20% "marking rate" would be applied to this S/N parameter. A target would then be denoted by 6 parameters: range, bearing, peak level, mean of the surrounding points, rms of surrounding points, and median of surrounding points.

(4) The desired data base would include 6 run geometries at each of 6 inserted target S/N for each of the 6 background sequences of 50 pings each available in the FM-RDT data base. This would represent

(U-FOUO) an enormous amount of data, both generating and processing; some method of streamlining must be produced in order to make this task a reasonable one.

(5) Initial runs would be straight-line, "high" S/N runs to assure evaluation; further data would be generated after examining initial data to get a better idea of the most desirable combinations.

(C) One 50-ping sequence with a strong inserted target was "digitized" with as much information as the system then provided. The "digitization" amounted to recording on digital magnetic tape from the DDP-516 (via the data link and CDC 3200) the "raw" output (16 msec averaged on each beam) from the beamformer for the full range scale (10,000 yd in this case). These data were then processed using a 32 msec averaging time, and copies were sent to both General Electric and TRACOR for the purpose of establishing data handling software for their respective machines. Further data production will be performed upon verification of data handling compatibility by all parties concerned.

2. Beamformer Checkout

(U-FOUO) Before using the digital beamformer for generation of data, a cursory checkout of parameters was made. Dynamic range and bandwidth were determined to be adequate to handle tape recorded (PME) data by inserting a test set signal and varying amplitude and frequency. It was noted during this procedure that, at certain frequencies (very near 5 kHz), a modulation of the envelope out of the averager of up to about 18% occurred. The modulation frequency was clearly related to the difference between the input frequency and the center frequency for the system. Because this magnitude modulation had not been predicted by any of the simulation work, a program which exactly simulates the hardware was used to determine whether errors in magnitude of a factor 1/4, 1/2, 2, or 4 on 1, 2, or even 3 staves could cause this kind of

(U-FOUO) error. It was noted that one stave (the most signigicant) off by 1/4 or 4, or 2 staves off by 1/2 or 2, would not cause this size error at the center frequency. However, at slightly off the center frequency, such a modulation could be seen. It then became clear that the magnitude of the modulation is caused by the particular parameter chosen: the maximum error occurs because the phase shift for pairs of staves on either side of the beam axis is exactly the same (except for sign) even including the sampling time between staves. If a particular signal phase which produces the maximum error (on one stave, and therefore 2 staves) is constant over a time long enough that the averager does not average over a cycle of the modulation (difference) frequency, then the maximum possible error will propagate through the system. Hence, the total error can be ±1 dB (including the envelope approximation error) if the input waveform happens to have a constant frequency and phase which produces the maximum error for a period of about 8 msec (or 16 msec, if this averaging time is used). This condition is unlikely enough for cw data, and virtually impossible for FM data, so that the data presently being processed is almost certainly not affected to this extent (the almost 1 dB peak-to-peak error for the envelope estimation process is still there).

(U-FOUO) Beam patterns were computed for the output of the beamformer by inputting from the PME data recorded aboard the USS WITEK (SS 848) by pulsing a small source transducer suspended off the bow of the ship. The beam patterns so obtained had about 1 1/2 dB peak-to-peak variations from pulse-to-pulse (cw pulses about 30 msec long near the carrier) with side lobes occasionally as high as -15 dB relative to the major lobe. The combination of these measurements plus the normal beam pattern measurements led to the conclusion that the beamformer was functioning as designed and providing useful data. However, the size of the possible errors from beam-to-beam makes questionable the process of interpolation between beams to obtain higher than 7 1/2° bearing resolution. More detailed tests are planned for the future.

3. <u>AN/SQS-23 - DDP 516 Data Link System Tests</u>

(U-FOUO) Spectrum analysis of data digitized from the AN/SQS-23 playback system and transferred via the data link to the CDC 3200 and thence to magnetic tape indicated a significantly smaller bandwidth than anticipated. Accordingly, tests were set up to test the entire system for bandwidth. To test the system from buffer amplifiers to magnetic tape, a sine wave input was digitized and frequency analyzed, with frequency steps of approximately 100 Hz from 4000 Hz to 6000 Hz. The system was found to be completely flat over this range. A random noise generator was then played into the system via the test set, and the audio beamformer output was digitized and spectrum analyzed. The resulting plots showed the system response to be exactly as expected: approximately 380 Hz at the 3 dB down points. It was concluded that what we saw was what we got.

4. <u>Local S/N Processor</u>

(U-FOUO) In the meeting with General Electric, TRACOR, and NAVSHIPS, it was pointed out that rather than peak signal-to-local mean noise ratio $\left((\text{Peak Signal})/(\mu_{\text{Noise}})\right)$ the statistic on which to threshold, peak signal minus local mean noise-to-local rms noise $\left((\text{Peak Signal} - \mu_{\text{Noise}})/(\sigma_{\text{Noise}})\right)$ should be used to assure uniform false alarm rate. Because σ_{Noise} is not computable in real time for the present set of parameters, this option would not be available for operator tests. It was thus decided that the mean noise level would be used, but that both σ_{Noise} and the median of the noise would also be computed and included with each target candidate.

(U-FOUO) It seemed desirable to know the relationship between the various proposed methods of computing S/N for known input data and, if possible, the relationship between these and other methods generally

(U-FOUO) employed. To get an idea of these relationships, a Rayleigh sequence was generated and "decayed" exponentially to coincide roughly with observed data. This sequence was then passed through the following types of S/N processors.

(1) Peak Signal/μ_{Noise} .

(2) (Peak Signal - μ_{Noise})/σ_{Noise} , where noise is computed in local area around target.

(3) (Peak Signal - μ_{Noise})/σ_{Noise} , where noise is computed in split window around target.

(U-FOUO) Each of these processors was used with "raw" data (decayed Rayleigh) and averaged data (averaging time, 32 msec), and types (1) and (2) were used with and without a local peak requirement. It was found, as expected with these synthetic data (since $\frac{\mu(t)}{\sigma(t)}$ = constant), that the false alarms for each of the cases could be obtained from each of the other cases by either slightly complicating the threshold criteria or by lowering the threshold. Insofar as it was checked, the "high level" false alarms were either the same (or contiguous with the same points) whether or not the local maximum criteria were used and whether or not averaging was employed. It was concluded that the relative maximum criteria would not degrade detection and, since the clutter rate is lowered by nearly a factor of 3 at a given threshold level using this criteria, it should be employed in producing the CAD test data.

5. Semicoherent Processor

(U-FOUO) Some processing gain computations were made in an effort to compare the $\ddot{\Phi}$ processor (see QPR 1) to a "completely coherent" processor (replica correlator) and an incoherent processor (detector/averager). Four "delay line" target models were used (1) a point reflector, (2) a 2-point reflector target with equal target strengths and 0.4 msec separation, (3) a 4-point reflector target (equal relative target strengths and relative separations 3.2 msec, 6.4 msec, and 9.6 msec),

(U-FOUO) and (4) a 30-point reflector target, modeled after a real bow aspect submarine echo. The transmit waveform was a linear FM slide 51.2 msec in length with a 400 Hz sweep in frequency. Processing gain in decibels is defined as

$$20 \log_{10} \left\{ \left[\frac{\text{Peak Signal + Noise}}{\text{rms Noise}} \right]_{out} \Big/ \left[\frac{\text{rms Signal}}{\text{rms Noise}} \right]_{in} \right\} ,$$

for the replica correlator;

$$20 \log_{10} \left\{ \left[\frac{\text{Peak(S+N)} - \mu_{\text{Noise Envelope}}}{\sigma_{\text{Noise Envelope}}} \right]_{out} \Big/ \left[\frac{\text{rms Signal}}{\text{rms Noise}} \right]_{in} \right\} ,$$

for the detector/averager; and

$$10 \log_{10} \left\{ \left(\sum_{\Delta} [\text{Envelope(S+N)}]^2 \Big/ \sum_{\Delta} [\text{Envelope(N)}]^2 \right)_{out} \Big/ \left[\frac{\text{rms Signal}}{\text{rms Noise}} \right]^2_{in} \right\} ,$$

for the $\ddot{\Phi}$ processor, where the $\sum_{\Delta}$ implies summation over the envelope-squared values whose corresponding instantaneous frequency slope ($\dot{\Phi}$) was within $\frac{\Delta}{2}$ Hz/sec of the desired value.

(U-FOUO) Three values of Δ were tried, with the results shown in Table I. It was found that, because of the infinite range of $\ddot{\Phi}$ which the data can take on, the noise, which along with the signal was filtered through a 400 Hz wide (3 dB points) RC filter, was distributed sparsely in the desired Δ, so that the number of data points of noise may have been insufficient. Nevertheless, the $\ddot{\Phi}$ processor seems to be holding its own with the correlator on the average over all cases. The principal

(U-FOUO)

TABLE I

PROCESSING GAIN COMPARISON FOR
COHERENT, SEMICOHERENT, AND INCOHERENT PROCESSORS

(Simulated Target in Bandlimited Gaussian Noise;
Processing Gains are in Decibels)

No. of Reflectors	Δ	$\ddot{\Phi}$	Correlator	Det/Avg.
Input S/N = 20 dB				
1	500	11.9 dB	14.0	7.8
	1000	10.4		
	2000	9.0		
2	500	11.7	14.5	8.3
	1000	11.2		
	2000	10.6		
4	500	16.7	9.9	8.7
	1000	16.8		
	2000	14.4		
30	500	17.8	14.5	11.1
	1000	16.0		
	2000	13.3		
Input S/N = 10 dB				
1	500	10.5	14.2	8.0
	1000	8.2		
	2000	5.8		
2	500	10.3	14.7	8.6
	1000	7.3		
	2000	5.2		
4	500	10.6	10.3	8.9
	1000	10.8		
	2000	9.7		
30	500	13.9	14.3	11.1
	1000	11.1		
	2000	11.6		
Input S/N = 6 dB				
1	500	7.3	14.3	8.2
	1000	6.6		
	2000	4.2		
2	500	7.8	14.9	8.8
	1000	3.1		
	2000	3.8		
4	500	6.7	10.7	9.0
	1000	12.0		
	2000	9.3		
30	500	12.3	14.2	11.0
	1000	10.0		
	2000	10.4		

(U-FOUO) point to be concluded from the work summarized in Table I would seem to be the enormous complexity involved in comparative experimental evaluation of signal processor for realistic parameters: an analytic approach would be highly advantageous here.

6. FFT

(U-FOUO) A comprehensive internal report covering all previous Signal Physics work on the FFT was completed in this quarter. A shorter paper on the novel reordering and multivariate techniques was also completed and is now being cleared for publication in the open literature.

(U-FOUO) New power-of-two routines were produced which offer a 15% speed gain over previous programs. In addition to being very close to the theoretical limit of efficiency, the integer FFT allows the user to scale the data during execution if desired. Modified versions of both the floating-point and integer routines were generated to provide efficient programs for transforming real arrays and multivariate arrays. Applications include faster algorithms for smoothing of power spectra, quadrature correction, multiping processing, and hologram correlation.

7. Normal Mode Propagation Modeling

(U-FOUO) The existing model for implementing the bilinear normal mode was brought up to date and simplified wherever possible. Provision was made for modification of the new version to incorporate a curvilinear velocity profile. Numerical problems in the technique used to obtain fast, accurate programs for the Airy functions and Hankel functions used in the model were overcome by building a double-precision package. The numerical difficulty was in the algorithm for generating a continued fraction from an asymptotic or Taylor expansion; the technique for manipulating a curvilinear velocity profile involves, as an intermediate

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(U-FOUO) step, generating a continued fraction from a summed series of Tschebyscheff polynomials by using the same algorithm. The numerical difficulty at this point is apparently eliminated, and no other serious numerical problems are expected.

8. Trip to NUC by Dr. Beard and Mr. Pitt

(U-FOUO) A visit with Drs. Pedersen, Gordon, and Bucher at NUC led to a great deal of constructive communication and several references that would be helpful in developing propagation models. NUC requested, and were sent, our Airy function routines. Work at NUC on surface (sea state) effects will be incorporated into our later models if possible; progress to date seemed to be promising.

(U-FOUO) Dr. Beard and Mr. Pitt also visited with Dr. Royce Allen, NUC, who described the NUC development of a composite, "real time" (seagoing) propagation model, containing versions of ray theory, normal mode theory, and empirical models. The composite model was pieced together from several Navy laboratory sources, and is being tailored to fit into a Nova computer for a sea trip in the very near future.

9. Meeting at NUC

(C) On 26-30 April, Dr. Wood and Mr. Pitt (ARL), Mr. Buske (NAVSHIPS), Messrs. J. Kingsbury and H. Newman (NUSC), and Messrs. B. Allen, M. Pederson, J. Stewart, and L. Strauss met at NUC to discuss programs of mutual interest. NUSC personnel described the history and present status of the LORAD program, NUSC personnel described their approach to development of an advanced system based on the same concept (convergence zone operation), and ARL personnel described the classification and computer aided detection work in which ARL is involved. The meeting served to indicate the problems to be expected in convergence zone

(C) operation: Real false alarms do exist, and the low data rate and loss of high resolution information will make classification perhaps a more difficult task than for surface duct. However, since the nonsub population problem is virtually unknown, it may be true that only very strong targets cause false alarms, so that size and motion can reduce possibilities to either submarines or surface ships. Certainly, insufficient data now exists from which to draw meaningful conclusions.

10. Data for NSRDC

(U-FOUO) During the period 1-3 June, Messrs. T. Kooij and A. Roesler brought two analog magnetic tapes containing explosive echo ranging data for digitization and preliminary analysis at ARL, primarily STARLITE analysis. A small amount was digitized at a 40 kHz rate and spectrum analyzed. It was determined that very little data existed past about 10 kHz, so that a 20 kHz sampling rate would be sufficient. The data were thus passed through 2 stages of low pass Butterworth filters, giving a rolloff of 24 dB/octave with the 3 dB point at 7.5 kHz, and a 1 sec segment from each echo-ranging cycle was digitized. Computer main frame problems during digitization of part of the data required some of the data to be redigitized, and an A/D hardware failure during this period resulted in a third digitization. A fourth digitization of a longer segment of some of reverberation was done for analysis at ARL. During this procedure, it was noted that a second and third echo were being received from secondary propagation paths. Several of the earliest arriving echoes from these two paths were subsequently digitized, and consideration is being given to digitization of the entire sequence. The decision will ultimately be made on the basis of NSRDC's desire to process these data.

F. Operations Analysis Section
(R. K. Goodnow)

1. Detection Testing with the Digital Display

(U-FOUO) During this quarter, the Navy Reserve personnel have been used to help set several parameters for the baseline sonar digital display research model. One of the major tasks of the Signal Physics Division during the past year has been the development of a single-target classifier, and a semiautomatic detector/preclassifier to indicate targets to which the operator should direct the classifier. We have assembled as a research tool a display converted from a AN/UQS-1 console with an X-Y + $\rho\theta$ joystick which controls a full-time range/bearing cursor. The display is driven by the Honeywell DDP 516 computer with information derived from the digital scanner and beam-former. This assembly of equipment is not a prototype nor a developmental model, but an experimental tool to allow us to optimize with the parameters of the display and of the display's controls.

(C) First, detection performance was determined for these subjects with the sonar, using the MIP Performance Test as the testing instrument. Results are given in Table II, line 1 presenting the average detection levels of the ARL personnel who were used as subjects for the MIP testing and line 2 showing the average detection levels for the Reserve Program (RP) subjects. Note that lower detection levels indicate better performance, since the target/background ratio was increased in regular steps throughout the test items. Line 2 shows test results that are from 0.3 to 2.0 dB higher than those found in line 1 with the average being 1.3 dB. It must be assumed that the reason for this "worse" performance is the standard Navy audio beam search pattern used by the RP subjects. The operator using this search procedure typically trains the audio beam off the starboard aft quarter for one

(C) TABLE II

AVERAGE TARGET/BACKGROUND RATIO LEVELS (in dB) FOR TARGET DETECTION UNDER THREE TEST CONDITIONS, BY MIP PERFORMANCE TEST ITEM

Condition/Item	1	2	3	4	5	6	7	8
ARL Subjects, MIPped Sonar	12.6	9.3	14.6	16.0	15.9	13.8	17.7**	14.0
Reserve Subjects MIPped Sonar	14.6	11.2	16.1	17.2	17.0	14.1	13.0**	15.0
Reserve Subjects Digital Display No. 1	14.6	11.0	14.4	15.4	15.6	15.1	13.5**	14.8

** Only 2 RS detected this target, vs 3 for ARL.

(C) ping, trains it about 10° forward for the next, and so on until it is pointed ahead of the ship. He then trains to the port aft quarter (about 200 to 220° rel) and moves it forward until he has it trained ahead again. This is repeated over and over, with the operator attending much more to the audio than to the video. Most of the subjects here paid very little attention to the video presentation, making their detections of the targets almost solely on the basis of hearing them. Thus, their detection of a target depends on the audio beam being pointed at the bearing of the target sometime after the target signal level is high enough for it to be heard above the background. The ARL subjects had no audio presentation and thus were forced to conduct their search completely visually. This resulted in an average detection level 1.3 dB lower than that found by using the Navy's systematic search procedure.

(C) The subjects were then given preliminary testing runs to aid in the determination of display parameters for the digital display. A simplified block diagram of the digital display is given in Fig. 2. Several changes were made in the display program as a result of the preliminary testing, resulting in a display that we thought would closely match the MIPped sonar display. Results of this testing are given on line 3 of Table II. These results show that this set of display parameters results in a detection performance slightly better (average 0.6 dB) than that found on the MIPped sonar for the same subjects.

(C) The next step in this testing will be the use of an "improved," area AGC rather than the "range ring" AGC used in MIP and the first digital display test. It is hoped that this work can be started early in the next quarter.

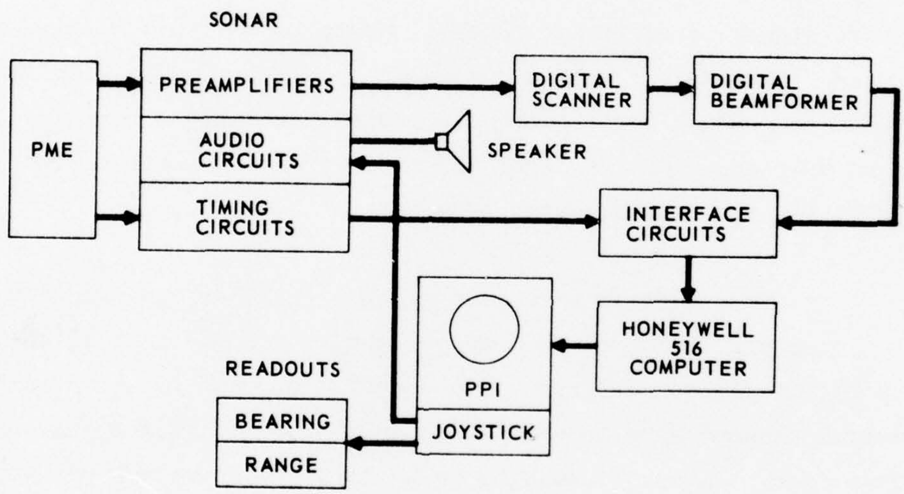

FIGURE 2
DIGITAL DISPLAY BLOCK DIAGRAM

ARL - UT
AS-72-2
RKG - DR
1 - 7 - 72

2. Other Work

(U-FOUO) Other work carried out during this quarter included the preliminary steps for the generation of a new detection test, a second version of the MIP Performance Test. It is feared that multiple exposures to the same instrument will lead to learning of the test items, including approximate locations of the targets that are to be detected, which will lead to loss of validity of the instrument. The new test will be slightly longer (12 vs 8 items), and the sonar trainer will be used to position the targets. The target initial positions, courses, speeds, etc., have all been chosen, maneuvering board plots of these target runs have been laid out, and relative position plots have been made for all targets. Bearings and ranges for 1 min intervals on the 20 k range scale and 1/2 min intervals on the 10 k range scale have been tabulated from the plots.

(U-FOUO) The background recordings that will be used for assembling these test items will be chosen from the same backgrounds used for the MIP test. This will permit mixing of the test items, so that many combinations of test items can be used in detection testing. Early next quarter this test will be taped, from taping scenarios that will be laid out for each item. This work should be completed during July, and determination of baseline performance on this test will be carried out by testing the subjects using the MIPped sonar.

(U-FOUO) Also during this quarter, an analysis was made of operator performance on the expanded B-scan, and operator performance on the Operator Classification Performance Test further analyzed. The main object of these analyses was the determination of consistently classified (or misclassified) targets across the 11 subjects of the Reserve Testing Program, and the 37 subjects of the FASWS contingent. Further analysis of these classification test results will be carried out during the next quarter.

G. <u>Naval Ship Systems Command Display Advisory Panel (C. L. Wood)</u>

(U-FOUO) The NAVSHIPS Sonar Display Panel sponsored a Sonar Display Symposium at NRL on 26 and 27 May 1971, for some 150 attendees. Seventeen technical papers were presented and a users perspective was presented by Mr. D. A. Bell, Technical Director of PMS-386.

(U-FOUO) The topics and their chairmen were:

1. New Display Concepts - C. L. Wood, ARL
2. Display Computer Symbiosis - A. Gerlach, NRL
3. Overview of Sonar Displays and the Man-Machine Interface - J. P. Jenkins, NAVSHIPS
4. Display System Relationships - John Hammond, NUC
5. Display Devices and Techniques - Ronald Betsworth, NUC
6. Methods of Display Evaluation - Donald Aldrich, NUSC
7. Introduction to Management and Displays - C. D. Smith, NAVSHIPS

(U-FOUO) The Symposium papers were prepublished by NRL.

H. <u>Computer Applications Section (J. K. Vaughan)</u>

(U-FOUO) Most of the work performed during the second quarter of 1971 pertained to program modification, data collection, and the initial development work for an automatic single-target classification system. The data collection included data from the digital beamformer for development of the computer aided detection system being developed by General Electric and TRACOR, and the data required as a base for the development of an automatic classification system.

(U-FOUO) Program modifications were required to expand program utility and to provide for a new length for the identification record. The

(U-FOUO) identification record was increased from 20 words to 121 words to provide storage for information which will be required by the single-target classification system. The expansion of the record forced all programs to be changed to accommodate it. A complete list of the information placed in the 121-word identification record by the various programs is shown in Appendix A.

(U-FOUO) A new data record format was also conceived for data that will be used as base for the single-target classification system. Previously, quadrature components of a signal were placed in 2 separate data records, each preceded by an identification record. The new format places the x component in the upper half (12 bits) of a word and the y component in the lower half of a word for each pair of quadrature components. This allows the signal to be represented in one data record with only one identification record. More importantly, however, the new format provides greater flexibility for collecting data via the CDC 3200 - DDP 516 data link for storage on digital tape.

1. New Programs

(U-FOUO) The new programs developed during the quarter were pertinent to data collection via the data link, testing of the data link, and the development of parameter extraction algorithms for the single-target classifier.

(U-FOUO) STATIST - The input source for this program is data stored on digital tape which was collected from either the digital beamformer or the video scanner of the PME/AN/SQS-23 playback facility. As the name suggests statistics of these data are extracted. The first step is the formation of a density table from which the following statistics are computed and printed on the line printer: histogram, mean, variance, skew, and kurtosis.

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(U-FOUO) LINE - This program was written to process data collected on analog tape and digitized with the CDC 3286 conversion controller. Sources of the data include the model SKIPJACK at LTTS and the split-beam scanner from the PME playback facility. The program was later modified to process data collected from the PME facility via the data link. The program was used primarily as a developmental tool in determining the optimum thresholding technique and the best line-likeness indication for data from the split-beam scanner.

(U-FOUO) CLASS - This program was initiated, but not completed, during the quarter. The input for the program will be the classification parameters extracted by the split-beam, audio, and video processors. The output of the program will be a ping-by-ping classification.

(U-FOUO) Several programs were generated for the CDC 3200 - DDP 516 data link. These include two programs to test the data link and several versions of one program to collect various sets of data.

(U-FOUO) READ516 - This program is designed to check the CDC 3200 READ (DDP 516 WRITE) section of the data link by inputting data from the DDP 516. The data consists of a record 2048 words long. The record is a binary counter which runs from 0 to 7777_8. The data records can optionally be recorded on magnetic tape and/or the line printer. The following information is available for display on the CDC 3200 console: record length, number of errors per record, total number of errors, and the total number of records received.

(U-FOUO) WRITE516 - The CDC 3200 WRITE (DDP 516 READ) section of the data link is checked with this program and the companion program written for the DDP 516 computer. The program writes a 4096 12-bit byte data block to the DDP 516. This data block can be either a binary counter running from 0 to 7777_8 or 12-bit bytes which are alternately zeros and ones (00007777_8).

(U-FOUO) Several programs were written to collect data from the PME playback facility. These programs are essentially variations of a basic data collection program and are subject to later revision and modification as experience is gained from data collection.

(U-FOUO) The first version was designed to input one identification record from the DDP 516 and as many data records as required to represent the data being digitized by the A/D converters connected to the DDP 516. This technique of handling data necessitated the modification of TAPEOUT, which is discussed later. This version of the program was used to collect data from the digital beamformer for the computer aided detection systems being developed by General Electric and TRACOR.

(U-FOUO) The second version of the program was designed to input multiplexed data from the DDP 516, demultiplex the data, and output three different data records on digital tape. The data collected with this program were the audio, video, and split-beam data which will be used as a learning set for the single target classification system.

(U-FOUO) The other programs generated during the quarter were concerned with covariance matrices. The covariance matrix was computed and written onto magnetic tape as temporary storage. Other programs were written to input the rows or specific elements of each row from the matrix for display on the incremental plotter.

2. New Subroutines

(U-FOUO) Three new subroutines were written. Two of these were used in development of a single-target classification system.

(U-FOUO) CLEARSYS - This routine clears the CIO (CDC 3200 system central input/output routine) tables when under system control of Input/Output. The tables which are cleared are the CST (Channel Status Table) and the UST (Unit Status Table). This allows recovery of program control after the computer has been MASTER CLEARED without reloading the program into core. The routine is a very valuable tool for debugging programs, in particular, those concerned with the data link.

(U-FOUO) LEAST - A weighted least-squares fit to a straight line is generated by this subroutine. It was designed primarily for fitting the split-beam phase difference data. The initial version minimized the square of the vertical distance from the phase difference. However, the fit which was obtained depended upon the orientation of the x-y coordinate system. Consequently the routine was modified to minimize the square of the perpendicular distance from the phase difference data point to the straight line. This proved to be independent of the coordinate system orientation.

(U-FOUO) THRES - This subroutine as well as the routine LEAST were incorporated into the program LINE which was discussed earlier. Basically, the routine thresholds the data in a 2-step fashion to obtain the information considered to be a target. This is accomplished by computing the mean (μ_N) and the standard deviation (σ_N) of the noise, which is assumed to be the first 100 data points from the split-beam correlation processor. A first threshold is obtained from the relation $\mu_N + K\sigma_N$. The variable K was inserted for experimental purposes. All data above the threshold are then used to compute a mean for the signal μ_S. The final threshold is then given by $\mu_S \cdot \sigma_N / \mu_N + \mu_N$. All data above this threshold are retained for further processing.

3. Program and Subroutine Modification

(U-FOUO) Conversion from the 20-word identification format to the new 121-word format affected nearly all of the operating programs. Those modified for the identification record will not be individually mentioned.

(U-FOUO) Input/Output routines which were modified include NPUTPING, FINDSEQ, TAPECARD, TAPESEQ, INPUTAPE, and TAPEOUT.

(U-FOUO) NPUTPING - Two items were changed in this routine which inputs data from magnetic tape into a 2-dimensional array in core. First it was modified to accept unpacked data (one sample per word) as provided by the digital beamformer. Secondly, a negative value for the number of bearing cells which are to be averaged indicates that only every nth bearing cell should be accepted and no averaging should take place.

(U-FOUO) FINDSEQ - Another entry point (NEXTSEQ) was added to FINDSEQ. This allows the programmer to input the next data sequence into core regardless of the sequence number given in the identification record.

(U-FOUO) TAPECARD - The logical units of digital tapes are assigned by this routine according to the field into which the tape numbers are placed on a data card. It was modified to allow the routine to be executed only one time. Other calls to the routine simply return control to the calling program.

(U-FOUO) TAPESEQ - This routine, which has been discussed in detail in previous reports, has been modified to accept data written on digital tape in the new quadrature format.

(U-FOUO) TAPELIST - The option to stop printing the information read from tape into the CDC 3200 core and read the next tape record to be

(U-FOUO) printed was added. This affords the user the capability to selectively list any portion of a record on digital tape without reloading the program.

(U-FOUO) RECARD - A check for an END-OF-DATA card was added to this program. This addition allows batch copying of programs by returning program control to the start of the programs upon recognition of an END-OF-DATA card.

(U-FOUO) HUNTER - Briefly this routine determines the beginning and ending points of a signal by a thresholding technique. An optional parameter was added to the routine. This parameter optionally returns to user the location of the first point of the extracted signal relative to the region being considered.

(U-FOUO) QUADCOR - This program (which computes a correlation envelope from data in quadrature format) was modified to take advantage of many routines written since its inception.

(U-FOUO) BEAMFORMER - Simulation of the digital beamformer is accomplished with this program. An option to use the $(x + 3/8\ y)$ square root logic was incorporated.

(U-FOUO) A.TO.D - Many parameters in the 121-word identification record are important to some data processing programs, not to mention their bookkeeping value. This general purpose A/D program was modified to force the user to input the following information into the identification record via the console typewriter (1) the analog tape number, (2) the rate at which the A/D converter will be operating, and (3) the parameter N for data to be taken in quadrature where $N = 4f_o/S$ and S is the sampling rate between the x and y quadrature components.

(U-FOUO) From this information the center frequency (f_o) under consideration can be computed. Additionally the user may option to change this information during execution of the program.

(U-FOUO) FREQNCY - This program was modified for two different reasons. Firstly, it provided an easy means of studying the $\ddot{\Phi}$ processor using FFT's for smoothing of the data and the generation of the derivatives to obtain the quantity $\ddot{\Phi}$. Secondly, the program was modified in several ways to determine the best method for smoothing the instantaneous frequency function and the envelope of the data. In the final result, smoothing the instantaneous frequency function and the envelope after their formation proved to be a much better technique than smoothing the quadrature components before the computations.

(U-FOUO) DIFPLOT - A more generalized version of this 2-dimensional plotting program was completed. Listed below are options which may be taken.

INPUT FORMAT

Integer - May be displayed without modification, as the envelope of the data, as the phase of the quadrature components, or as the phase difference of two signals.

Floating Point - May be displayed without modification, the product or the square root of the product of two floating point arrays.

PLOTTER OUTPUT

linear axes

semilog axes

(U-FOUO) INPUTAPE - This subroutine was modified in two very important ways. Firstly, the ability to read across record gaps with only one

(U-FOUO) call to the routine was added. This is important when several data records are required to represent the information and only a selected portion of it is requested by the processing program. This change provides nearly all existing programs the capability to handle multiple record data without changing the programs.

(U-FOUO) The second change to this routine was necessitated by the new quadrature format. The routine was given access to the identification record so that the new quadrature format could be recognized and the data transferred to core in the correct manner.

(U-FOUO) TAPEOUT - As mentioned earlier, data collected from the digital beamformer showed the necessity for a routine to output multiple data records per identification record on digital tape. This was accomplished with two entry points in TAPEOUT. Their usage is outlined below:

CALL TAPEOUT (LUN, K, ID, DATA)

where

LUN - logical unit

K - returned status

ID - 121-word identification record

DATA - data record to be written

The length of the data record is located in the first word of the identification record. This routine writes the 121-word identification record and the data record. However, if the data array is omitted, only the identification record is written.

(U-FOUO) CALL DATAOUT (LUN, K, DATA)

This routine provides the capability of writing multiple data records. The length of the records is given in the first word of the identification record. It may be called as many times as desired, but must be preceded by a call to TAPEOUT so this identification record is defined.

I. Visitors

(U-FOUO) Date	Visitor	
6-7 April	David Middleton,	Consultant

Current areas of applied research work in modeling and signal processing were discussed.

26 April	GianCarlo Vettori Ed Hug	SACLANT ASW Research Centre La Spezia, Italy
	Roger H. Prager Leo P. Mulcahy	NUC San Diego, California

Mr. Vettori made a formal presentation to the ARL staff of some results of his work in acoustic propagation modeling in the Mediterranean Sea. Mr. Hug reviewed his work in space frequency processing (STARLITE), also for the ARL staff. The ARL classification sonar program was reviewed for the visitors; informal discussions followed.

27 April	William F. Gess Hugh W. Hadley	General Electric Syracuse, New York

Information was exchanged on General Electric's adaptive beamformer and the ARL split-beam processor. Topics of mutual interest in ASW detection and classification were discussed.

3-5 May	Kenneth E. Buske,	Naval Ship Systems Command Washington, D. C.

Present status of the ARL classification program was reviewed. The immediate and long range goals were outlined and discussed.

19 May	Donald W. Winfield David L. Jordan John P. Lindhuber	General Electric Syracuse, New York
	Hugh A. Reeder J. Jerry Dow William B. Butler	TRACOR Austin, Texas
	Kenneth E. Buske Dolly R. Gauggel	Naval Ship Systems Command Washington, D. C.

(U-FOUO) Discussed data requirements for 3-dimensional data analysis as described in Section E of this report.

20-21 May	Kenneth E. Buske Woodie L. Thompson Dolly R. Gauggel Matthias M. Giwer	Naval Ship Systems Command Washington, D. C.

A formal review of the ARL classification program was made. Individual systems and concepts that were discussed included the single target classifier, digital sonar, and baseline sonar.

28 May	Edward G. Liszka,	NAVORD Washington, D. C.

There was an exchange of information on split-beam processing.

1-3 June	Theo Kooij Alvin Roesler	NSRDC Washington, D. C.

Discussions were held concerning a coordinated model study effort planned for Lake Travis during 1972. The visitors toured the Lake Travis Test Station facilities and heard a progress report on ARL classification work. Coordination with personnel to use the Honeywell computer at ARL was accomplished.

8-18 June	Lorraine R. Dutcher,	NSRDC Washington, D. C.

Work continued on computer programming and checkout for Theo Kooij.

16-18 June	Theo Kooij Pam Sinex	NSRDC Washington, D. C.

Efforts were completed on programming computer for space frequency analysis of sonar data.

J. Reports Issued

(U-FOUO) 1. Plemons, T. D., "Spectra, Covariance Functions, and Associated Statistics of Underwater Acoustic Scattering from Lake Surfaces," Applied Research Laboratories Technical Report No. 71-17 (ARL-TR-71-17) The University of Texas at Austin, 3 April 1971.

2. Mikeska, E. E., "Analysis of Acoustic Echo from Nose Section of a Model Submarine," (U) Applied Research Laboratories Technical Memorandum No. 71-10 (ARL-TM-71-10) The University of Texas at Austin, 3 April 1971. CONFIDENTIAL

APPENDIX A

121-WORD ID

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LATEST REVISION 17/JULY/71

WORD	FUNCTION	PROGRAM GENERATING WORD
1	RECORD LENGTH OF DATA RECORDS	ALL
2	SEQUENCE NUMBER	ALL
3	NUMBER OF SAMPLES PER SWEEP	A.TO.D.23 , DATA LINK
4	NUMBER OF RECORDS PER 121 WORDS IDENTIFICATION	ALL
5	SECTOR BEARING (DEREES RELATIVE TO NORTH)	ALL
6	SECTOR RANGE (MSEC/8)	A.TO.D.23, A.TO.D, DATA LINK
7	NUMBER SWEEPS PER DATA RECORD	A.TO.D.23 , DATA LINK
8	ANALOG TAPE NUMBER	A.TO.D.23, A.TO.D, DATA LINK
9	INITIAL ANALOG FOOTAGE	A.TO.D.23, A.TO.D, DATA LINK
10	DAY-MONTH-YEAR	ALL
11	SYNC RATE (HZ) RATE AT WHICH DATA WERE DIGITIZES 1. SAMPLING RATE FOR UNIFORMALLY SAMPLES DATA 2. RATE PER COMPONENT FOR QUADRATURE DATA	ALL
12	BEAMFORMER AVERAGING TIME	DATA LINK
13	PING NUMBER RELATIVE TO INITIAL ANALOG FOOTAGE OR TO RUN NO.	A.TO.D, DATA LINK
14	THRESHOLD 20 LOGF(X)*2**16	DETECTOR
15-16	NORMALIZATION FACTOR (FLOATING POINT) NUMBER BY WHICH DATA MUST BE MUTIPIED	ALL
17	ODD WHERE ODD = 4(FO)/Q AND Q IS THE QUADRATURE SAMPLING RATE BETWEEN THE X AND Y COMPONENTS	ALL THAT GENERATE QUADRATURE DATA
18	FO(HZ) - CENTER OF BANDWIDTH UNDER CONSIDERATION	ALL THAT GENERATE QUADRATURE DATA

LATEST REVISION 1/JULY/71

WORD	FUNCTION	PROGRAM GENERATING WORD
19	DATA FUNCTION	ALL
	(1) UNIFORMALLY SAMPLED	
	(2) QUADRATURE SAMPLED	
	(4) POWER SPECTRUM	
	(10B) PACKED	
	(20B) RECTIFIED	
	(40B) ENSEMBLE	
	(100B) ADDED DATA	
	(200B) ENVELOPE	
	(400B) FLOATING POINT	
	(1000B) SCANNER DATA	
	(2000B) CORRELATION FUNCTION	
	(4000B) DETECTOR OUTPUT	
	(10000B) FORMAT II FOR QUADRATURE DATA - DATA LINK TRESTII	
	(20000B) THE COMPLIMENT OF TWO	
	(100000B) SIGNS OF QUADRATIC DATA HAVE BEEN CORRECTED	
	FOR EXAMPLE WORD (19) = 601B WOULD INDICATE THE DATA IS AN UNIFORMALLY SAMPLED ENVELOPE IN FLOATING POINT FORMAT	

LATEST REVISION 1/JULY/71

WORD	FUNCTION	PROGRAM GENERATING WORD
20	DATA TYPE OR SOURCE	ALL
	(0) NON-SUB	
	(1) STERN ASPECT	
	(2) QUARTER ASPECT	
	(3) BEAM ASPECT	
	(4) BROAD BOW ASPECT	
	(5) BOW ASPECT	
	(6) CHANGING ASPECTS	
	(7) STARLITE	
	(10B) LITS DATA	
	(20B) MISCELLANEOUS	
	(40B) ANALYTICALLY GENERATED DATA	
	(100B) STAVE DATA	
	(200B) AUDIO	
	(300B) SPLIT BEAM A (LEFT)	
	(400B) SPLIT BEAM B (RIGHT)	
	(500B) SCANNER	
	(600B) DIGITAL BEAMFORMER	
	(1000B) PLOTTER COMMANDS	
	(2000B) FM TRANSMIT	
	(4000B) RDT TRANSMIT	
	(10000B) SDT TRANSMIT	
	(20000B) ODT TRANSMIT	
21	RESERVED	
	TIME OF DAY (HR * 2**12 + MIN * 2**6 + SEC)	ALL
23	ORIGINAL DIGITIAL TAPE NUMBER OF FIRST SIGNAL	ALL
24	ORIGINAL DIGITAL TAPE NUMBER OF SECOND SIGNAL	ALL
25	ORIGINAL DIGITAL TAPE NUMBER OF THIRD SIGNAL	ALL
26	ORIGINAL SEQUENCE NUMBER OF FIRST SIGNAL	ALL
27	ORIGINAL SEQUENCE NUMBER OF SECOND SIGNAL	ALL

28	ORIGINAL SEQUENCE NUMBER OF THIRD SIGNAL	ALL
29	REFERENCE TIME (515 COUNT-ELASPED TIME SINCE PREVIOUS PING) (MSEC)	DATA LINK
30	DATA SHIP NAME	DATA LINK
31-60	SHIP SPEED (KTS.)	DATA LINK
61-90	SHIP COURSE (DEG RELATIVE TO NORTH)	DATA LINK
91	RUN NUMBER	DATA LINK
92	TARGET BEARING (DEGREES RELATIVE TO NORTH)	DATA LINK
93	TARGET RANGE (YARDS)	DATA LINK
94	LEFT HALF-FIRST SIGNAL QUANTIZATION 100B * EXP. + AMPLITUDE RIGHT HALF-SECOND QUANTIZATION 100B * EXP. + AMPLITUDE	CORRELATION CORRELATION
95	PING NUMBER RELATING TO START OF DIGITAL TAPE	DATA LINK
96	PUSLE LENGTH (MSEC)	DATA LINK
97	(3200) ELASPED TIME BETWEEN INTERUPTS	DATA LINK
98	TARGET BEARING (DEGREES RELATIVE TO NORTH,NEAREST 0.1B DEGS)	DATA LINK
99	SHIP COURSE (DEGREES RELATIVE TO NORTH,NEAREST 0.1B DEGS)	DATA LINK
100	NUMBER OF CHANNELS OF MULTIPLEXED DATA	ALL
103	NUMBER OF BAD DATA POINTS DUE TO DATA LINK (516)	DATA LINK
104	NUMBER OF BAD DATA POINTS DUE TO DATA LINK (3200) AUDIO AND SPLIT BEAM ONLY	DATA LINK
119-120	PROGRAM NAME	ALL
121	62473163B	ALL

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13. ABSTRACT

U

Work during this quarter primarily concerned various aspects of the hardware and software associated with a single-target classifier. ~~(U-FOUO)~~

Additional work is reported concerning split-beam processing, studies of reverberation and target statistics, and operator and committee activities. (U-FOUO)

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14 KEY WORDS	LINK A		LINK B		LINK C	
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Detection						
Reverberation						
Beamforming						
ROC curves						
Software						
Computer						
Computer interface						